ADF

Saskatchewan Agriculture
Development Fund

Keeping the agriculture and food industries competitive through Research, Development and Demonstration.

Technical/Final Report
to
Saskatchewan Agriculture Research Fund

The Effect of Plant Growth Regulators On Morphological Characteristics, Grain Yield and Yield Components Of Winter Wheat c.v. Norstar

ADF-S-0037

S-85-05-0005/1-85-66
1-84-37

92-06587/

5-86-05-0067

The Effect of Plant Growth Regulators On Morphological Characteristics, Grain Yield and Yield Components Of Winter Wheat (*Triticum aestivum* L.) c.v. Norstar

P.M.S. Bandara and L.V. Gusta
Crop Development Centre, University of Saskatchewan, Saskatoon, Sask., S7N 0W0

The effect of the plant growth regulators Cycocel-extra, Terpal C, Cerone, Bayleton and Mefluidide on plant height, yield and lodging was determined over a three-year period at three locations in Saskatchewan. Plant height was reduced by the plant growth regulators. Depending upon the growing conditions, the yield of Norstar winter wheat may be increased slightly with Cycocel-extra. However, high rates of Cycocel and late application of Terpal-C may reduce grain yield. The main reason for a reduction in grain yield was due to a decrease in tiller number.

THE EFFECT OF PLANT GROWTH REGULATORS ON MORPHOLOGICAL CHARACTERISTICS, GRAIN YIELD AND YIELD COMPONENTS OF WINTER WHEAT (**Triticum aestivum L.**) v. Norstar

P.M.S. Bandara and L.V. Gusta
Crop Development Centre, University of Saskatchewan, Saskatoon, Sask. S7N 0W0

INTRODUCTION

Winter Wheat and fall rye readily lodge when grown under condition of high moisture and high rates of nitrogen. If lodging occurs at the heading stage, yields can be reduced by 60%. Lodging also makes the harvest of the crop difficult and may cause sprouting in the head giving rise to poor grain quality. Growth regulators have been demonstrated to decrease plant height, increase the elasticity of the stem, increase root growth and increase the drought and cold hardiness of winter wheat. Plant growth regulators may increase grain yield by increasing productive tillers, increasing the number of grain per ear and by increasing the grain filling period. To this date, only limited work has been reported on the effect of plant growth regulators on winter cereals in western Canada.

OBJECTIVES:

1. To determine the effect of plant growth regulators (PGRs) on some selected plant morphological characteristics and maturity of Norstar winter wheat.
2. To determine the effect of PGRs on grain yield and yield components of Norstar winter wheat.

MAIN OBSERVATIONS MADE FROM PREVIOUS STUDIES

The following important effects were observed from previous studies, conducted at Kamsack and Quill Lake sites in 1985 and 1986 crop seasons, respectively:

1. Late applied N (Zadok's GS 32) had no effect on grain yield.
2. Higher rates of PGRs adversely affected grain yield and yield components, especially number of heads per square metre.
3. Late application of Mefluidide enhanced the vegetative growth at Kamsack.
4. Cerone applied at the high N level and at the higher rate produced the most adverse effect on grain yield at Quill Lake.

The following modifications in treatment combinations were made, in 1987 crop season:

1. Elimination of late applied N and use of a medium amount of N application (80 kg N/ha).
2. Eliminate the high rates of application of PGRs.

3. Include all 5 tested PGRs viz. Cycocel-Extra, Terpal-C, Bayleton, Mefluidide, and Cerone at all sites.

4. Test the PGRs at two locations, Quill Lake and Preston Field, Saskatoon.

5. Times of applications to remain same as in 1985 and 1986 crop seasons.

6. Applied concentrations were:

		C1	C2	C3	C4
Cycocel-Extra	(g ai/ha)	0	460	920	1380
Terpal-C	(g ai/ha)	0	322	644	966
Bayleton	(g ai/ha)	0	70	140	210
Mefluidide	(g ai/ha)	0	7.5	15.0	22.5
Cerone	(g ai/ha)	0	120	240	360

RESULTS AND DISCUSSION

Grain yield and its components namely number of spikes per square metre, number of kernels per spike, and 1000 grain weight were statistically analyzed for both locations. Treatment means were compared using orthogonal contrast, and Dunnett's t test. Table 1 summarizes the ANOVA tables for both locations.

Table 1. SUMMARY OF ANOVA FOR BOTH LOCATIONS.

Location	Parameter	P	T	P*T	C(p)	C*(P)
Quill Lake	Grain yield	*	*	ns	*	ns
	No. of heads per m^2	ns	ns	ns	*	ns
	No. of kernels per spike	ns	*	ns	*	*
	100 kernel wt.	ns	ns	ns	ns	ns
Preston	Grain yield	*	ns	ns	**	ns
	No. of heads per m^2	*	*	ns	**	*
	No. of kernels per spike	ns	*	ns	**	ns
	100 grain wt.	ns	ns	ns	*	ns

Legend: P = Type of plant growth regulators
T = Time of application of PGRs
C(P) = Concentration of PGRs nested within type of PGRs
ns = nonsignificant
* = significant at 5% level
** = significant at 1% level

1.0 Grain Yield

The overall average grain yield obtained from Quill Lake and Preston were 1.8 mt. ha-1 and 1.55 mt. ha-1, respectively. A similar yield response to PGRs was obtained at both locations. The overall effects on grain yields produced by Cycocel-Extra, Terpal-C, and Bayleton were similar at both locations whereas Mefluidide and Cerone treated plants produced significantly lower yield than Cycocel-Extra treated plants (Table 2).

Table 2. EFFECT OF TYPE OF PGRS ON GRAIN YIELD AT QUILL LAKE AND PRESTON SITES.

Type of PGRs	Grain yield		Dunnett's t test results		
	Quill Lake	Preston		Quill Lake	Preston
		Kg/ha			
Cycocel-Extra	1878.77	1615.40	Cycocel vs Terpal	ns	ns
Trepal-C	1863.57	1563.94	Cycocel vs Bayleton	ns	ns
Bayleton	q872.47	1595.55	Cycocel vs Mefluidide	*	*
Cerone	1684.58	1496.66	Cycocel vs Cerone	*	*

Preston sites

The application of PGRs at late stages produced significantly lower yield than early applied plants at Quill Lake whereas at Preston site this effect was not significant even though the trend was similar.

Table 3. EFFECT OF TIME OF APPLICATION OF PGRS ON GRAIN YIELD

Quill Lake		Preston	
early applied	late applied	early applied	late applied
Kg/ha		Kg/ha	
1825.05	1776.17	1573.31	1541.28
*		ns	

The effect of concentration of PGRs on grain yield was tested for significance separately on the basis of type of PGRs.

A significant, partially positive quadratic effect on grain yield was observed from the Cycocel Extra treated plants as the concentration was increased from 0 to 1380 ai.g/ha-1 (3.0 litre/ha) at Quill Lake (Table 3). At the Preston site, the response to Cycocel Extra was negative even though the nature of effect was quadratic (Table 3).

Terpal-C at Quill Lake had produced a partially positive quadratic effect on grain yield, whereas at the Preston site, Terpal-C produced a cubic effect on grain yield (Table 3). Bayleton at Quill Lake had a partially positive

quadratic effect on grain yield, whereas at the Preston site, Terpal-C had a cubic effect on grain yield (Table 3). A similar type of response was observed from Mefluidide treated and Cerone treated plants at both locations. Both of the chemicals reduced grain yield with increasing concentration (Table 3).

Table 3. EFFECT OF PGRS CONCENTRATION ON GRAIN YIELD AT QUILL LAKE AND PRESTON SITES.

Location		Co[1]	C1	C2	C3
		Kg/ha			
Quill Lake	Cycocel	1907.59	1934.65	1923.78	1749.02
	Terpal-C	1894.49	1920.72	1892.80	1746.27
	Bayleton	1891.72	1929.67	1936.30	1731.89
	Mefluidide	1862.29	1743.;2	1621.14	1588.08
	Cerone	1878.45	1710.22	1620.15	1529.49
Preston	Cycocel	1677.36	1654.51	1623.56	1506.16
	Trepal-C	1643.35	1569.92	1572.18	1470.30
	Bayleton	1659.59	1620.24	1581.23	1521.11
	Mefluidide	1661.54	1558.21	1477.03	1362.99
	Cerone	1668.76	1575.90	1433.24	1308.72

Co - plants not treated with PGR

2.0 NUMBER OF HEADS PER M2

The average effect of individual PGRs used in the study on number of heads per m2 was not significant at the Quill Lake site whereas at the Preston site, Cerone reduced the number of heads per m2 more than Cycocel-Extra treated plants (Table 4).

Table 4. EFFECT OF PGRS ON NUMBER OF HEADS PER M2 AT QUILL LAKE AND PRESTON SITES AS COMPARED TO CYCOCEL EXTRA.

Type of PGRs	No. of heads/m2	
	Quill Lake	Preston
Cycocel Extra	296.75 (standard)	287.70 a (standard)
Terpal-C	287.95	284.92 a
Bayleton	287.08	294.08 a
Mefluidide	279.75	280.91 a
Cerone	282.83	277.41 b
	ns	Dunnett's t value 8.130

The average effect of time of application of PGRs on number of heads per m2 was not significant at the Quill Lake site whereas the Preston site, late applied PGRs resulted in significantly lowered number of heads per m2 (Table 5).

Table 5. EFFECT OF TIME OF APPLICATION OF PGRS ON NUMBER OF HEADS PER M2 AT QUILL LAKE AND PRESTON.

Quill Lake		Preston	
early	late	early	late
290.00	283.75	289.75	280.28
ns		*	

The number of heads per m2 was affected by the concentration of PGRs at both locations. At Quill Lake, Cycocel Extra produced a partially positive quadratic effect on number of heads per m2 as the concentration was increased whereas at the Preston site the response was negatively linear (Table 6).

Bayleton treated plants at Quill Lake produced a partially positive quadratic effect on number of heads per m2. At the Preston site, the time of application of the PGRs had a significant effect on the number of heads/m2. The late treated plants had a lower number of heads per m2 as compared to the early treated plants. This response was negatively cubic (Table 6).

At the Quill Lake and Preston sites, Mefluidide and Cerone treated plants had a reduced number of heads per m2 as the concentration of the PGR's was increased. A negative linear effect on the number of heads per m2 was observed from Cerone treated plants at Preston site. The Mefluidide treatment produced a negative cubic effect with increasing concentration (Table 6).

Table 6. EFFECT OF CONCENTRATION OF PGRS ON NUMBER OF HEADS PER M2 AT QUILL LAKE AND EFFECT OF T*C(P) AT PRESTON SITE.

Location	Type of PGRs	C0	C1	C2	C3
Quill Lake	Cycocel Extra	296.16	310.16	300.83	279.83
	Terpal-C	298.00	295.66	288.33	269.83
	Bayleton	294.33	301.83	283.33	268.83
	Mefluidide	297.33	288.83	278.00	254.83
	Cerone	306.83	292.66	272.83	259.00
Preston			early application		
	Cycocel Extra	307.66	294.33	288.66	272.00
	Terpal-C	304.00	295.00	290.66	273.00
	Bayleton	313.66	313.00	294.33	286.33
	Mefluidide	310.66	301.33	265.66	257.66
			late application		
	Cycocel Extra	317.33	300.33	265.33	256.00
	Terpal-C	306.00	280.33	280.00	250.33
	Bayleton	322.00	279.33	278.00	266.00
	Mefluidide	309.00	302.00	257.00	244.00
	Cerone	306.33	289.33	260.33	236.66

3.0 NUMBER OF KERNELS PER SPIKE

The late application of PGRs reduced the number of grains per spike as compared to the early application of PGRs at both locations. At Quill Lake, the higher concentrations of Cycocel-Extra reduced the number of kernels per spike when applied at the late stage of growth (Table 7). However, Cycocel-Extra had no effect on kernels per spike if applied at the early growth stage. At the Preston site, Cycocel-Extra had no effect on kernels per spike at either time of application. At Quill Lake, the early application of Cerone had little or no effect on number of grains per spike irrespective of concentration. However, high concentrations of Terpal at the late application dramatically reduced kernels per spike (Table 7).

The number of kernels per spike was unaffected by the Bayleton treatment at Quill Lake, whereas at Preston the grain number was reduced linearly as the concentration of Bayleton was increased (Table 7).

Mefluidide and Cerone applied at both locations resulted in reduced grain number with increasing concentration. An early application of Cerone had little effect on kernels per spike at Quill Lake, whereas the late application had a negative effect on kernels per spike (Table 7).

Table 7. EFFECT OF CONCENTRATION OF PGRS ON NUMBER OF KERNELS PER SPIKE AT THE PRESTON SITE AND EFFECT OF T*C(P) ON NUMBER OF KERNELS PER SPIKE AT QUILL LAKE.

Location	Type of PGR	C1	C2	C3	C4
		Early application			
Quill Lake					
	Cycocel Extra	28.46	28.96	29.53	28.63
	Terpal-C	29.70	30.53	31.86	28.43
	Bayleton	30.36	29.73	30.33	29.23
	Mefluidide	29.00	30.36	29.06	28.60
	Cerone	30.76	29.40	29.50	28.43
		Late application			
	Cycocel Extra	29.96	29.66	28.33	26.40
	Terpal-C	28.86	29.80	31.10	28.80
	Bayleton	29.53	39.19	29.40	29.83
	Mefluidide	29.73	28.13	26.76	25.90
	Cerone	30.40	30.33	26.80	23.00
Preston					
	Cycocel Extra	30.08	31.25	30.50	28.33
	Terpal-C	30.85	29.26	30.16	29.46
	Bayleton	30.98	30.95	30.90	29.18
	Mefluidide	31.35	30.25	28.25	27.70
	Cerone	31.15	29.78	28.55	27.38

4.0 1000 KERNEL WEIGHT

None of the PGR's study had a significant effect on the 1000 kernel weight at Quill Lake. At the Preston site, Terpal-C, Mefluidide, and Cerone had no effect on the 1000 grain weight whereas Cycocel-Extra had a quadratic effect and Bayleton with increasing concentration linearly reduced the 1000 grain weight (Table 8).

Table 8. EFFECT OF CONCENTRATION OF PGRS ON 1000 GRAIN WEIGHT AT QUILL LAKE AND PRESTON SITES.

Location			C0	C1	C2	C3
Quill Lake						
	Cycocel Extra	(ns)	30.70	31.60	31.22	30.91
	Terpal-C	(ns)	31.21	31.12	30.94	30.42
	Bayleton	(ns)	30.78	31.36	31.14	30.99
	Mefluidide	(ns)	30.96	30.94	30.42	30.19
	Cerone	(ns)	32.20	31.82	32.33	31.60
Preston	Cycocel Extra	(*)	27.15	27.26	27.43	26.22
	Terpal-C	(ns)	26.63	26.29	26.53	26.79
	Bayleton	(*)	27.23	27.05	26.58	26.33
	Mefluidide	(ns)	26.94	26.23	26.65	26.30
	Cerone	(ns)	27.02	26.39	26.52	26.34

Morphological characteristics such as plant height, neck length, lengths of first three basal internodes at harvesting stage, flag leaf area, flag leaf dry weight and number of green leaves at flag leaf stage were also measured. Samples are still being analyzed.

Conclusions:

The application of Cycocel Extra, Terpal-C, Mefluidide and Cerone produced significantly shorter statured plants at all locations in 1985, 1986 and 1987. This response increased linearly as the concentrations of chemicals increased. The application of these plant growth regulators at the late growth of stages (Zadok's GS 32) produced a more pronounced effect on plant height only at Kamsack. Bayleton shortened plant height at Quill Lake in 1986 and 1987; whereas there was no effect at Kamsack and Preston.

A late application of extra N (45 kg/ha more than the recommended dose) had no effect on grain yield in 1985 and 1986. The early application of Cycocel-Extra, within the range of 0-2.0 litre/ha, slightly increased grain yield. The application of 3.0 litre/ha resulted in a reduction in grain yield. A late application of Cycocel resulted in lower grain yields as compared to an early application except at Preston, Saskatoon.

A similar type of effect on grain yield was observed with the application of Terpal C. A late application of Terpal-C resulted in reduced grain yield as compared to an early application. Bayleton application linearly reduced grain

yield at Kamsack, Quill Lake (1986) and Preston whereas at Quill Lake (in 1987) there was no reduction in yield with increasing concentration of Bayleton. The application of Mefluidide and Cerone linearly reduced grain yield with increasing concentration. The higher concentration of Cerone (1.5 litre/ha) applied with high levels of N had the most adverse effect on grain yield at Quill Lake in 1986.

The most important factor to account for the reduction in grain yield due to the application of PGR's was a reduction in the number of effective tillers per plant. While Cycocel-Extra, Terpal-C and Bayleton slightly reduced or linearly reduced the number of heads per m^2 with the season, Mefluidide and Cerone treated plants always had a linearly reduced number of heads per m^2.

None of the plant growth regulators affected the number of grains per spike at Kamsack. High N reduced the number of grains per spike whereas the 1000 grain weight was increased. Bayleton applied at Quill Lake in 1986, 1987 had no effect on the number of grains per spike whereas Cycocel, Terpal-C and Cerone reduced the number of grains per spike. Cerone and mefluidide with increasing concentration, linearly reduced the number of grain per spike in 1986 and 1987.

The most stable yield parameter was 1000 grain weight. Cycocel-Extra had no effect on 1000 grain weight at Kamsack and Quill Lake (1987), whereas at Preston the 1000 grain weight increased and at Quill Lake (1986) linearly reduced as the concentration Cycocel-Extra was increased. Terpal-C treated plants had reduced grain weight only at Quill Lake (1986) if applied at the late growth stage, but had no effect on grain weight.

Bayleton had no effect on grain weight at Kamsack and Quill Lake (1987) whereas it significantly reduced grain weight at Quill Lake (1986) and Preston. Cerone had no effect on grain weight in 1987 whereas in 1986 grain weight was reduced. The application of Mefluidide had no effect on grain weight at all locations.

In conclusion, the plant growth regulators Cycocel-Extra, Terpal, Mefluidide and Cerone reduced plant height. Therefore if the environmental conditions resulted in excessive plant growth which would result in lodging, plant growth regulators would be of benefit. Under moist conditions, Cycocel-Extra increased yield slightly although lodging was not a problem. However, under dry conditions, none of the plant growth regulators increased yield. This was primarily due to a decrease in the number of producing tillers. A late application of nitrogen had no effect on grain yield in all cases tested.

List of Publications

To be submitted to the Canadian Journal of Plant Science.

Bandara, P.M.S. and L.V. Gusta. The effect of plant growth regulators on morphological characteristics, grain yield and yield components of winter wheat (**Triticum aestivum** L.) c.v. Norstar.

Personnel Involved

P.M.S. Bandara	85%
B.J. O'Connor	15%
M. Boyachek	15%
T. Spencer	10%
T. Raines	15%

Acknowledgements

The authors gratefully acknowledge the grant given to L.V. Gusta by SARF. Without this financial support, this study would not have been possible.

1-85-66

The effect of growth regulators on winter survival, lodging and yield of Norstar winter wheat and Muskateer fall rye

P.M.S. Bandara[1] and L.V. Gusta[2]

Abstract: Plant growth regulators (PGR); cycocel, terpal C, mefluidide, cerone and bayleton were applied either in the fall or spring. Four levels of growth regulator were applied at two growth stages in the spring and two levels in the fall. Two levels of nitrogen were applied in the early spring prior to growth and at growth stage (GS) 7 according to Feeke's scale.

Cycocel and cerone applied at both growth stages, reduced plant height. This reduction was a function of application levels where as the concentration increased, plant height is reduced. Cerone applied at GS 10 reduced plant heights from 72 cm tall for non treated plants to 60 cm tall for plants treated at the highest concentration.

Bayleton treated plants produced more tillers per plant with increased application rate, however at the highest concentration there was a reduction. Above ground biomass decreased with increased concentration levels of bayleton. High concentrations of cycocel and cerone reduced the number of heads per meter^2 at harvest.

High rates of nitrogen increased the number of grains per spike, but reduced 1000 kernel weight. Yield was not affected by high nitrogen levels, the type of PGR, and the application rate. The highest concentration of PGR applied at the second growth stage, did cause a reduction in yield. Bayleton had no effect on yield.

Cycocel and terpal C had a significant effect on the maintenance of cold hardiness and to a lesser extent mefluidide, bayleton and cerone.

Plants treated with PGR regenerate more and larger roots in the spring.

---

[1]Graduate student.
[2]Senior research scientist.

Materials and Methods

Norstar winter wheat was sown at Kamsack on September 9, 1984 into canola stubble, at Quill Lake on September 12, 1985 into barley stubble and at Saskatoon on September 9, 1986 into canola stubble. An alternate site at Quill Lake was sown on August 15, 1986 into summerfallow in the event the winter wheat in Saskatoon will not overwinter.

The plots were fertilized at the time of seeding with 11-55-0 at a rate of 55 kg/ha in 1984 and 1986 and 90 kg/ha in 1985. Nitrogen fertilizer was broadcast in early May at a rate of 90 kg/ha on the whole site. A second nitrogen application was applied to half the site (45 kg/ha) at growth stage (GS) 7 of Feeke's scale.

Experimental design was a split-split-nested design replicated three times. The main plot was plant growth regulators (PGR). The sub-plot was rate of nitrogen applied, the sub-sub-plot was time of application of the PGR and the sub-sub-sub plot was the rate of application. The plot size in 1984-85 was 1.5 x 6 cm with a row spacing of 20 cm. In 1985-86 the size was 2.1 x 4.8 m (15 cm row spacing).

Four plant growth regulators (PGR) were applied as a foliar spray in both the fall and spring at the following rates, each season;

Cycocel 0, 2, 2.5, 3 l/ha

Terpal C 0, 1, 1.5, 2 l/ha

Bayleton 0, 70, 140, 280 g(ai)/ha

Mefluidide 0, 10, 20, 30 g(ai)/ha (1984-85)

Cerone 0, 0.5, 1.0, 1.5 l/ha (1985-86)

In the spring the plants were sprayed at GS 3 to 4 and GS 7. Cerone was sprayed at GS 7 and GS 10. Bayleton is also a fungicide which has growth regulating properties. At growth stage (GS) 10.5 the following measurements were determined:

(a) Flag leaf area

(b) Flag leaf dry weight

(c) Number of leaves per plant

(d) Number of tillers per plant

(e) Above ground biomass.

The following determinations were made at the time of harvest (August 19, 1985 and August 25, 1986):

(a) Plant height

(b) Total tiller number per plant

(c) Effective tiller number per plant

(d) Number of heads/m^2

(e) Number of grains per spike

(f) 1000 kernel weight

(g) Length of the basal internode of the stem

(h) Dry weight of the first 8 cm basal length of the stem

(i) Harvest index

(j) Above ground biomass

(k) Grain yield

(l) Grain protein content.

The growth regulators were applied at two rates and two dates in the fall. Samples were collected in the first week of November and stored at $-3^{o}C$ for cold hardiness level tests conducted throughout the winter in a controlled temperature freeze test.

Plants were collected in April and transplanted to a sand culture to determine the root regeneration abilities of the winter wheat plants in the spring. After 7 days the plants were rated for shoot growth, root number per plant and root length.

416 heads/m^2 produced on plots at the higher nitrogen level. High nitrogen had no affect on the effective tiller number. For all growth regulators tested there was a reduction in the number of heads/m^2 as the rate of application increased. Cycocel reduced the number of heads per $meter^2$ to 412 at the high rate from 431 on the non treated plots. Cerone had an even more significant reduction effect from 433 m^2 for the control to 384 m^2 for the high rate.

1000 Kernel Weight

The higher nitrogen level reduced the 1000 kernel weight from 30 g to 28 g for all treatments. A significant reduction in 1000 kernel weight was observed from plants sprayed at GS 3 to 4 compared to those sprayed at GS 7. Cerone applied at the high rate at GS 10 caused the 1000 kernel weight to be reduced from 30 g to 28 g. Higher 1000 kernel weights were observed from plants sprayed with cycocel and bayleton than terpal C and mefluidide.

Number of Grains/Spike

Plants receiving the second nitrogen application at Kamsack had a higher number of grains per spike compared to plants receiving low nitrogen. However, at Quill Lake there was no nitrogen effect.

At the highest rate of PGR application; the PGRs significantly affected the number of grains/spike in plants. Plants sprayed with terpal C and cerone reduced the number of grains/spike from 30 for nontreated plants to 28 for treated plants. There was no significant effect with bayleton and cycocel. PGRs at the later growth stage resulted a greater reduction in the number of grains per spike when compared to the early growth stage application date.

Biomass

Biomass was reduced at the highest rate of PGR application except for cycocel. Bayleton had the greatest reduction effect. The control plants above ground biomass was 6.8 g. Plants treated with bayleton at the highest

application rate reduced the above ground biomass to 6.0 g. The number of leaves per plant was highest on plants treated with bayleton.

There was no significant increase in the number of leaves per plant with increases in nitrogen. The flag leaf area or flag leaf dry weights were not affected by PGR treatments.

Harvest Index

Application of PGRs and high nitrogen levels had no effect on the harvest index.

Grain Yield

Cycocel, irrespective over the range of concentration tested, increased the yield of grain at Kamsack, however, at Quill Lake there was no effect. Terpal C, mefluidide and cerone applied at the second application date had the greatest reduction in yield at the highest concentration. Other concentrations had no effect on yield. Bayleton in 1984-85 had no effect on yield but in 1985-86 yields were reduced at high rates of application.

Freezing Tolerance

The cold hardiness of Norstar treated in the fall with cycocel and terpal C were significantly more cold tolerant than the controls from January to March. The increased level of cold tolerance for plants treated with bayleton, mefluidide and cerone was to a lesser extent. Crowns of Norstar winter wheat treated with terpal C had a cold hardiness level of -22 at the beginning of February. Control plants could only tolerate $-15^{o}C$.

Root Regrowth

Plants treated with growth regulators regenerate more and longer roots in the spring. Plants treated with terpal C had the highest number of roots and the most roots per plant. The average length of the first root of the control was 15 mm, whereas the first root on plants treated with terpal C was 25 mm in length.

Impact

It has now been established that winter wheat can be successfully grown in Saskatchewan using the proper management technique. Both winter wheat and rye respond profitably to higher levels of nitrogen than do spring crops. However, in the northern part of the province, which is generally wet in the spring, high rates of nitrogen result in excessive growth. Fields of Norstar winter wheat 1 to 1.5 m high are not uncommon. The excessive growth results in lodging, diseases, poor water use and large amounts of straw. These result in harvest losses to the farmer and can result in harvesting costs being three times normal. Growth regulators such as CCC, cerone have been used in Europe for many years to reduce plant height, reduce lodging and increase yields. Research is needed in Saskatchewan to determine if growth regulators can be used on a commercial basis to increase yields, reduce lodging and increase water use efficiency.

Introduction

Increased production of winter wheat in Saskatchewan has been made possible by direct seeding into standing stubble. Stubble acts as a snow trap providing uniform insulation throughout the fields. Winter wheat provides more efficient crop moisture utilization, increased yields, erosion control, reduced production costs and access to a new wheat export. Nitrogen fertilization is a practical means of increasing production of wheat and the optimal use of nitrogen fertilizers is therefore of importance. The amount of nitrogen fertilizers used may be limited by the danger of lodging. Winter wheat and fall rye under high moisture and nitrogen fertilization results in excessive growth which may readily lodge. Research has shown that if lodging occurs at the heading stage, yields can be reduced by 60%. Lodging also makes the harvest of the crop difficult and may cause sprouting in the head giving rise to a poor grain quality. Growth regulatorss have been shown to decrease plant height, increase the elasticity of the stem, increase root growth and increase the drought and cold hardiness of winter wheat. Recent research in our laboratory has shown CCC to increase the cold hardiness of brome grass cell suspensions by 10^{o}C. These results suggest that growth regulators may have a role in increasing yield, quality and winter hardiness of winter cereals in Saskatchewan, while reducing harvesting time and costs. To this date, no work on winter cereals in western Canada has been reported and only limited work on spring cereals has been undertaken.

Objectives

(1) To determine the effect of growth regulators on the lodging resistance of winter cereals.

(2) To determine the effect of growth regulators on yield.

(3) To determine the effect of growth regulators on winter survival.

Materials and Methods

Norstar winter wheat was sown into standing stubble at Kamsack and Saskatoon on September 9 and 10 and fertilized with 11-55-0 at 50 kg/ha. Experimental design was a completely randomized block design replicated three times. On May 1, the plots at Kamsack received a broadcast application of 150 lbs/ac of 34-0-0. All the plots at Saskatoon were winter killed as a result of the early snowfall October 16, 1984.

Additional plots were selected at Kamsack and Kelvington. Experimental design was a split-split-split plot design replicated three times. The main plot was plant growth regulators (PGR). The sub plot was rate of nitrogen applied. The sub-sub plot was growth stge at which the PGR were applied. The sub-sub-sub plot was the rate of application of the PGR. Plot size was 1.5 x 6 meters with 4.8 in^2 being harvested. Row spacing was 20 cm.

At growth stage (GS) 10 according to the Feeks scale, the following measurements were determined.

(a) Plant height.
(b) Flag leaf area.
(c) Flag leaf dry weight.
(d) Number of leaves per plant.
(e) Number of tillers per plant.
(f) Dry weight of the total plant.

The following determinations were made at the time of harvest.

(a) Plant height.
(b) Total tiller number per plant.
(c) Effective tiller number per plant.
(d) Number of grains per spike.
(e) 1000 kernel weight.
(f) Length of the basal internode of the stem.
(g) Dry weight of the firsst 8 cm basal length of the stem.
(h) Harvest index.
(i) Aboveground biomass.
(j) Grain yield.
(k) Grain protein content.

The growth regulators cycocel, terpal C, mefluidide and bayleton were tested on Norstar winter wheat. Bayleton is also a fungicide which has growth regulating properties. Four levels of PGR were applied at GS 3 to 4 and at GS 7 according to the Feeks scale. Nitrogen was broadcast early in May and a second application of 45 kg/ha was applied to our half of the plots at GS 7.

Results and Discussion

Plant Height

The second application of nitrogen fertilizer did not affect the final plant height at Kamsack. Soil test results revealed that there was 90 kg/ha available NO_3-N in the soil that did not receive the second application of nitrogen. Therefore, nitrogen may not have been limiting. Kamsack received over 650 mm of rain during the growing season of 1985. Plants were excessively tall as a result of excess moisture and available nitrogen.

Terpal C applied at GS 7 had the greatest effect on plant height. Control plants were 128 cm tall versus 104 cm for the Terpal C treated plants.

Cycocel and mefluidide reduced plant height to a lesser extent than terpal C. Final height of the cycocel treated plants was 110 cm on average. There was no concentration effect if applied at GS 7. Plants treated at GS 3 to 4 with cycocel were 118 cm tall on average. Bayleton had no effect on plant height. The final height of plants treated with terpal C, cycocel and mefluidide at GS 7 were shorter than plants treated at GS 3 to 4.

Tiller Number

Plants which received the second nitrogen application and treated with terpal C had more tillers at GS 10.5 than terpal C treated plants receiving only the spring application of nitrogen. Bayleton reduced tiller number at GS 10.5 for plants grown under high nitrogen conditions. Mefluidide under low nitrogen conditions, increased tiller number at the low rates of application,

but decreased tiller number at the high rate of application. Under high nitrogen conditions, there was a linear increase in tiller number with rate of application.

The application of cycocel at GS 7 under high nitrogen conditions reduced the final tiller number. Mefluidide applied at GS 7 under low nitrogen conditions increased the final tiller number.

1000 Kernel Weight

Terpal C applied at GS 7 reduced the 1000 kernel weight, whereas cycocel, mefluidide and bayleton had no effect. The 1000 kernel weight from plants grown under high nitrogen conditions was reduced in comparison to plants grown under low nitrogen conditions. Plants receiving the high level of nitrogen had a higher number of seeds/spike in comparison to the plants receiving low nitrogen.

Biomass

The total number of leaves per plant increased as the rate of nitrogen was increased. The total number of leaves per plant was not influenced by the application of PGR at the GS 3 to 5. Mefluidide and bayleton applied at GS 7 produced more leaves than cycocel or terpal C applied at the same time. Terpal C applied at GS 7 resulted in a larger flag leaf area in comparison to the other PGR.

Harvest Index

PGR applied at GS 3 to 4 had no effect on harvest index. Cycocel applied at GS 7 increased the harvest index, whereas terpal C, bayleton and mefluidide had no effect. Cycocel applied had no effect on the harvest index.

Grain Yield

Cycocel, irrespective over the range of concentration tested, increased the yield of grain. Bayleton had no effect on yield, whereas mefluidide at the higher concentration reduced yield.